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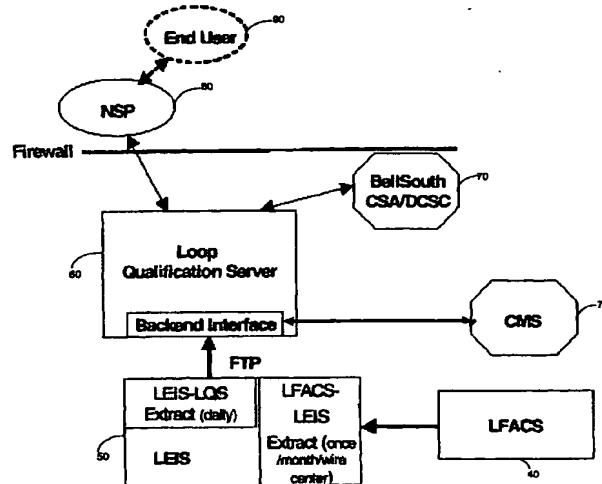
(57) Abstract: Loop qualification systems and methods involve evaluating Loop Make-Up (LMU) data to determine whether loops qualify for certain services, such as ADSL service or other digital services. The LMU data includes such information as whether the loop is comprised of copper, fiber, is a DLC, the length, resist zone, carrier zone, loading factor, the existence of a DAML, and taper code information. The loop qualification systems and methods obtain LMU data on existing loops and also information on loops that have not yet been completed. Network service providers (NSPs) interface with the loop qualification systems to determine whether certain lines are qualified for a service. The loop qualification systems also include web-based interfaces to allow both the NSPs and end users to make an inquiry as to the capability of a given loop.

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ADSL LOOP QUALIFICATION SYSTEMS AND METHODS

RELATED APPLICATIONS

This application claims priority to, and incorporates by reference, co-pending

5   provisional patent application Serial No. 60/148,911 entitled "ADSL LOOP QUALIFICATION SYSTEMS AND METHODS" filed on August 13, 1999.

FIELD OF THE INVENTION

The present invention relates generally to systems and methods for qualifying

10   lines for a service and, more particularly, to systems and methods for qualifying lines for digital service, such as Asymmetrical Data Subscriber Line (ADSL) service.

BACKGROUND OF THE INVENTION

The Public Switched Telephone Network (PSTN) is the backbone for providing

15   telephony services to business and individuals in the United States. In addition to telephony, the PSTN is increasingly being relied upon to carry data traffic. In fact, data traffic on the PSTN has become so heavy that it has surpassed the amount of voice traffic. One way in which the PSTN has evolved to meet these demands is to employ Digital Subscriber Lines (DSLs). The DSLs include Integrated Services Digital Network (ISDN)

20   lines and more recently Asymmetrical Digital Subscriber Lines (ADSL). ADSL is in many ways preferred over other DSLs since ADSL does not require the provisioning of any new lines but instead can be executed over a single twisted-wire pair, such as an existing telephone line.

In addition to Plain Old Telephone Services (POTS), an ADSL system also

25   permits full-duplex and simplex digital services with data rates from about 1.5 Mbits/second to 7 Mbits/second. An ADSL system uses a spectrum from about 26 kHz to 1.1 MHz for broadband data transmission and leaves the spectrum from about DC to 4 kHz for POTS. An ADSL system is more than capable of providing video-on-demand capability, video conferencing, data file transfer capability and can provide all of this

30   capability simultaneously with POTS. For additional information, reference may be made to American National Standards Institute Standard ANSI-T1.413-1995 which

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describes an ADSL system and an interface between a telecommunications network and a customer's installation and which is incorporated herein by this reference.

While ADSL can be executed over existing telephone lines, not all telephone lines are capable of carrying ADSL traffic. Consequently, when a customer orders ADSL

5   service, a technician is typically dispatched to the location to test the line. One way in which a technician tests the line is by trying to establish communications between an ADSL transceiver located at the customer's premises with an ADSL transceiver located at a central office. If the ADSL transceivers are able to communicate with each other to a satisfactory degree, then the ADSL services may be deployed at the customer's premises.

10   The need to dispatch a technician to the customer's premises before deploying ADSL services is a great inconvenience and has a high cost. The need to test the line places a great burden on the technicians who must be dispatched to the customer's premises. For areas that may have thousands if not millions of potential ADSL customers, using technicians to test the line at each customer's premises is impractical. In

15   addition to the enormous cost associated with the technicians, the need for an ADSL transceiver at the customer's premises also presents a substantial expense. This expense is often incurred by the customer before the customer even knows if ADSL are available. Even if the cost of the ADSL transceivers are absorbed by the service provider, the transceivers still require an outlay of capital before ADSL services can be deployed.

20   Other methods of qualifying lines for digital services involve testing that occurs at the central office. U.S. Patent Nos. 5,864,602, 5,978,449, and 6,084,946, which are incorporated herein by reference, describe various ways of qualifying lines for digital service. These methods generally involve applying an AC test signal and then measuring a tip-to-ring capacitance of a wire pair. Some of the methods described in these patents

25   involve additional measurements, such as measuring a second impedance of the wire pair at another frequency. Based on these measurements, the line is qualified to receive digital services if the measurements are within prescribed limits. While these methods avoid the need to dispatch a technician to the customer's premises, these methods still require testing to occur at the central office for each line.

30   The testing of lines to qualify them for new services is further complicated in that more than one company may provide the digital services over any given line. Whereas the incumbent local exchange carrier (LEC) would traditionally provide all local services

to the lines within its region, the opening up of the local loops to competition now makes it possible for competitive local exchange carriers (CLEC) to not only offer local telephony service but also to offer peripheral services, such as digital services. Providing all of these companies access to all of the lines in order to test them for potential serve is

5   impractical.

A need therefore exists for improved systems and methods for qualifying loops for ADSL services.

SUMMARY OF THE INVENTION

10   The present invention addresses the problems described above by providing systems and methods for qualifying lines for services. The systems and methods involve obtaining data on the characteristics of the lines. Preferably, this data is obtained from data gathered during engineering of the lines and/or from a database containing an inventory of the lines. The systems and methods receive requests as to the status of lines

15   for digital services and, in response to these requests, evaluates the data on the line characteristics. The systems and methods reply to the requests by providing the status of the lines, such as whether the lines are capable of receiving certain services. The systems and methods are preferably used in the qualifying of lines for Asymmetrical Digital Subscriber Lines (ADSL), although it may be used for other types of services.

20   The preferred systems and methods involve evaluating Loop Make-Up (LMU) information and, based on this evaluation, determining whether the loops qualify for enhanced digital services, such as ADSL. The systems and methods are preferably capable of evaluating loops having different configurations, such as copper, fiber, and DLC, and of eliminating those loops that would not qualify for the service. By

25   disqualifying certain loops, the number of loops that a technician must be dispatched to can be drastically reduced, thereby resulting in a considerable savings to the service provider. The invention also preferably is able to identify loops that will be capable of carrying services in the future and of qualifying lines that have not yet been completed.

In the preferred embodiment, the loop qualification system is employed by a Local

30   Exchange Carrier (LEC) and interfaces with network service providers for the digital services. The network service provider (NSP) can interface with the loop qualification system in a variety of ways, such as through e-mail or through a CORBA interface. In

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addition to front-end interfaces with the NSPs, the loop qualification system has back-end interfaces for receiving LMU data from other systems, such as a Loop Engineering Inventory System (LEIS) and network deployment information from a network planning organization. Preferably, the NSP has a Graphical User Interface (GUI) through which

5   information identifying lines may be inserted. This information on the lines is forwarded to the loop qualification system which then performs its analysis on the lines and returns the results to the NSP. This GUI may be accessible not only to the NSP but also through its customers or potential customers, such as through the Internet. The NSP preferably has a multi-threaded interface with the loop qualification system. A multiplexor within

10   the NSP provides a virtual real-time connection with the loop qualification system. In addition to the GUI and also the multiplexor, NSPs preferably also have the ability to send inquiries on lines in a batch-mode to the loop qualification system.

BRIEF DESCRIPTION OF THE DRAWINGS

15   The accompanying drawings, which are incorporated in and form a part of the specification, illustrate preferred embodiments of the present invention and, together with the description, disclose the principles of the invention. In the drawings:

Figure 1 is a block diagram of a local loop according to a first configuration;

Figure 2 is a block diagram of a local loop according to a second configuration;

20   Figure 3 is a block diagram of a local loop according to a third configuration;

Figure 4 is a block diagram of a loop qualification system according to a first aspect of the invention;

Figure 5 is a data model for the loop qualification system shown in Figure 4;

Figure 6 is a block diagram of a loop qualification system according to a second

25   aspect of the invention;

Figure 7 is a data model for the loop qualification system shown in Figure 6;

Figure 8 is a first example of a communication flow diagram for a loop qualification system;

Figure 9 is a block diagram of a loop qualification system illustrating a first set of

30   interfaces to end users and to LFACS;

Figure 10 is a block diagram of a loop qualification system illustrating a second set of interfaces to end users and to LFACS;

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Figure 11 is a second example of a communication flow diagram for a loop qualification system;

Figure 12 is a block diagram of a loop qualification system according to a third embodiment of the invention;

5   Figure 13 is an example of a data model for the loop qualification system of Figure 12;

Figure 14 is a block diagram of a multiplexor architecture for use by clients in interfacing with the loop qualification system;

Figures 15(A) and 15(B) are screen shots of client-side Graphical User Interfaces

10   for submitting telephone numbers or addresses for qualification to the loop qualification system; and

Figure 16 is a screen shot of a client-side interface for submitting telephone numbers via bulk submit.

15   <u>DETAILED DESCRIPTION</u>

Reference will now be made in detail to preferred embodiments of the invention, non-limiting examples of which are illustrated in the accompanying drawings.

ADSL services may be deployed at a customer's premises in a variety of different ways. Figure 1 illustrates one manner in which ADSL services are provided over an

20   existing twisted-paid copper wire. According to this configuration, the customer's premises 10 include a splitter 14 for directing the POTS signals to POTS devices 16, such as a conventional telephone, for directing ADSL signals to an ADSL device 18, such as a computer with an ADSL transceiver, and for directing the combined POTS signals and ADSL signals over a telephone line 20 to a central office 30. The central office 30

25   includes a Digital Subscriber Line Access Multiplexor (DSLAM) 32 and a switch 34, such as a 5E switch. The DSLAM 32 facilitates the transmission of ADSL data traffic between the customer's premises equipment and a Wide Area Network (WAN) 40, such as an Asynchronous Transfer Mode (ATM) network. The switch 34 within the central office 30 provides the connection to the remaining portion of the PSTN.

30   Another possible configuration in which a customer may receive ADSL services is shown in Figure 2. According to this configuration, the customer's premises 10 still include a splitter 14 for separating the POTS signals from the ADSL signals but differs

from the configuration in Figure 1 in that it includes a remote DSLAM 36. A remote
DSLAM 36 is desirable when serving large number of ADSL customers. The remote
DSLAM 36 is associated with a Digital Loop Carrier (DLC) 37 whereby the remote
DSLAM 36 is coupled to the central office 30 via a digital line 37.

5   A third possible configuration for providing ADSL services to a customer's
premises 10 is shown in Figure 3. In this example, a digital fiber 38 extends between the
central office 30 and an optical network unit (ONU) 39. The ONU 39 is located
relatively close to the customer's premises 10 and provides the necessary conversions
between electrical signals and optical signals.

10   The invention, according to preferred embodiments, is directed to systems and
methods for qualifying loops for enhanced services, such as ADSL services and other
digital services. The loop qualification system evaluates the ability of a loop to receive
the enhanced service and eliminates the need to dispatch a technician to every customer's
premises. The loop qualification system is able to disqualify loops that are determined

15   not to be capable of receiving the enhanced service and, by the process of elimination, is
consequently able to identify a set of loops that are potential candidates for the enhanced
service. The loop qualification system is preferably conservative in its evaluation in that
this set of potential loops contains loops that known to be capable of receiving ADSL
services as well as some loops that possibly may not be capable of receiving the enhanced

20   service. The loop qualification system therefore substantially reduces the number of
loops that may require testing by a technician.

         In addition to not requiring the dispatching of a technician, the systems and
methods of the invention do not require any measuring of line impedances at the central
office. Whereas conventional techniques for qualifying lines relied upon measuring the

25   impedance at one or more frequencies, the invention provides a less burdensome
approach by eliminating the need to do any central office measuring or testing. The
methods and systems of the invention are consequently also less burdensome on the
customers. The conventional techniques for qualifying lines involve disconnecting the
lines from the central office prior to measuring the impedance on the lines. The need to

30   disconnect the lines can translate into a reduction in the quality of service (QoS) provided
to the customers. Because the systems and methods of the invention do not require the
lines to be disconnected from the central office, the invention provides a more customer

friendly and higher QoS approach to qualifying lines.

The loop qualification system performs its evaluation of a loop based on data that refers to the characteristics of the lines. For a regional Bell operating company (RBOC), this Loop Make-Up (LMU) data includes data specifying the line as copper, fiber, DLC,

5   length, resist zone, count zone, loading factor, and DAML. This LMU data includes the type of line, length of line, impedance of line, and anything else that directly or indirectly refers to the features, aspects, parameters, or quality of the lines. By evaluating this LMU data, the loop qualification system eliminates those loops that are not qualified for enhanced services and identifies potentially capable loops.

10   The methods and systems according to the invention may be provided by a provider of the ADSL services or by the provider of other services, such as a Local Exchange Carrier (LEC). The LMU data need not be centrally located but may be dispersed to a plurality of locations. Many of the RBOCs rely upon a Loop Facility Assignment Control System (LFACS) for maintaining data on the inventory and

15   assignment of loops. The loop qualification system may therefore obtain LMU data from the LFACS in making its evaluation of the loops.

The invention is not limited in the manner in which LMU data is acquired. Figure 4 illustrates an example of a network for providing data from LFACS 40 to a loop qualification server 60, and Figure 5 illustrates a data model of a loop qualification

20   database. LFACS 40 is a legacy system for assigning loop facility in real-time during service activation process and has LMU data for all assigned loops. Rather than interfacing directly from the loop qualification server 60 to LFACS 40, which may have performance impact on the real-time service activation process through LFACS 40, the loop qualification server 60 receives data from a Loop Engineering Inventory System

25   (LEIS) 50. As shown in Figure 4, the loop qualification server 60 includes a backend interface 62 for receiving data from the LEIS 50. The LEIS 50, in turn, includes an interface 52 to the loop qualification server 60 and also an interface 54 to LFACS 40. The loop qualification server 60 preferably receives the data from LEIS 50 via File Transfer Protocol (FTP) and maintains a separate database at the loop qualification server

30   60 for storing the LMU data. The loop qualification server 60 receives network deployment information from a network planning organization and has an interface to the Customer Service Associates (CSA) located at the Data Customer Service Center (DCSC)

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70 supporting the ADSL servicing process.

On a daily basis the loop qualification server 60 polls an inbox to see if new files have arrived via FTP from LEIS 50. For each file in the inbox, the loop qualification server 60 processes the file and updates the database. The loop qualification server 60

5   determines whether a loop is qualified by evaluating the LMU data using a variety of criteria. For instance, if the loop is a foreign exchange line, the loop is loaded, has DAML, or has a Resist Zone (RZ) greater than 13, then the loop qualification server 60 determines that the loop is not qualified for ADSL. The above-mentioned criteria is suitable for eliminating loops having a configuration similar to that shown in Figure 1.

10 For configurations similar to that shown in Figure 2, the loop qualification server 60 preferably also considers a terminal Carrier Zone (CZ). A loop is disqualified if the terminal CZ value is greater than 9. For the configuration shown in Figure 3, the loop qualification server 60 determines that the loop is qualified if it is associated with an ONU 39.

15   The invention is not limited to these methods or manners of disqualifying loops. As will be appreciated by those skilled in the art, other LMU data may be considered when determining whether a loop is qualified for a certain service. Further, more sophisticated analyses may be developed to assist in the evaluation of loops. The reliance on other LMU data and the use of other methods of analyses is intended to be

20 encompassed by the invention.

For instance, the loop qualification server 60 may also evaluate loops based on their taper code. The loops are organized into tapers with many tapers located within a wire center. If one loop within a taper is determined to not be capable of receiving ADSL services, then the other loops within that same taper will likely also not be able to

25 accommodate ADSL services. This information on taper codes is preferably received from the network maintenance group when diagnosis was performed on a particular taper code.

The loop qualification system 60 may provide additional information other than whether a loop qualifies for ADSL service. For instance, the loop qualification system 60

30 can provide information on a projected speed a loop can support. The loop qualification system 60 may employ algorithms for deriving the projected speed based on LMU data or, alternatively, another system may derive the projected speed and populate LFACS 40

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with this information. If the speed band information is placed in LFACS 40, the loop

qualification system 60 retrieves this information indirectly from LEIS 50. The projected

speed can therefore automatically be delivered for every loop qualification inquiry. The

projected speed is significant since different levels of ADSL service is being offered with

5   these different levels varying in both upstream and downstream speeds. By delivering the

projected speed capability of a loop, the maximum level or class of ADSL can be inferred

and may be communicated to the end user 90 or NSP 80.

       As described above, the loop qualification system 60 is used to evaluate whether

existing loops are capable of receiving ADSL services. The loop qualification systems

10   and methods according to the invention may also be used to provide information on not

yet completed loops. Figure 6 provides an example of a network in which the LEIS 50

receives information on planned loops from Consumer Multimedia Services (CMS) 72.

The CMS 72 provides a file having information on planned dates for when certain loops

will provide data service via fiber. The loop qualification system 60 may therefore be

15   used in a proactive manner by notifying NSPs 80 or end users 90 of when ADSL service

may become available. Figure 7 illustrates a data model for the loop qualification server

database shown in Figure 6.

       As discussed above, the loop qualification system 60 can qualify an assigned loop

or a yet-to-be assigned loop based on telephone number. The loop qualification system

20   60 preferably also qualifies loops that do not have an assigned telephone number.

According to this aspect, the request, such as from an end user 90, for ADSL service is

made at the same time when a request is made for a POTS line. The loop qualification

system 60 ascertains the availability of ADSL without relying on the telephone number

but instead by such information as the address. The loop qualification system 60

25   determines whether potential loops for that address qualify for ADSL service and reserves

a particular loop. If the potential loops do not qualify for ADSL service, then the loop

qualification system 60 identifies other candidates and reserves a line that is capable of

supporting ADSL. The loop qualification system 60 performs its inquiry without an

assigned telephone in a variety of ways all of which are intended to be encompassed by

30   the invention. For instance, the loop qualification system 60 uses address information to

obtain a Wire Center/Taper Code or a serving terminal.

       The loop qualification system 60 may interface with other systems, service

providers, or other entities, such as end users 90, in any suitable manner. Figure 8
illustrates one example of how the loop qualification system 60 may interface with other
systems. As discussed above, the loop qualification system 60 receives LMU data from
the LEIS 50 through FTP. The loop qualification system 60 also has e-mail interfaces 64

5   with the NSPs 80 and with the DCSC 70. Through these interfaces 64, the NSPs 80
provide the loop qualification system 60 with inquiries as to whether certain telephone
numbers qualify for ADSL service. The loop qualification system 60 receives these e-
mails, processes the requests, and sends e-mail replies to the NSPs 80 with answers to the
inquiries. The information on whether certain loops qualify for ADSL service is also

10   desired by CSAs located at the DCSC 70. With reference to Figure 9, an end user 90 can
interface with the NSP 80 to determine whether the NSP 80 is able to offer ADSL
service. The NSP 80, in turn, interfaces with the loop qualification system 60 via e-mail
and relays the answer from the loop qualification system 60 to the end user 90. As will
be appreciated by those skilled in the art, a single NSP 80 may need to interface with a

15   plurality of LECs and, similarly, a single loop qualification system 60 may need to
interface with a plurality of NSPs 80.

       A loop qualification system 100 according to a further aspect of the invention is
shown in Figure 10. The reliance on e-mail to communicate loop qualification
information has several limitations. For one, the e-mail interface 64 does not provide

20   real-time information. The NSP 80 or end user 90 may want to know immediately
whether a certain loop is qualified for ADSL service. For instance, a customer 90 may
call the DCSC 70 and the DCSC 70 would desire an immediate response to the
customer's inquiry. The loop qualification system 100 shown in Figure 10 maintains the
e-mail interface 64 with the NSP 80 but also includes another interface 66. This second

25   interface 66 allows the NSP 80, end user 90, and DCSC 70 to interface with the loop
qualification system 100 on a real-time basis.

       The loop qualification system 100 shown in Figure 10 also includes a backend
interface 102 to LFACS through Hands Off Assignment Logic (HAL) 110. The LFAC-
LEIS extract occurs on a daily basis on a rotating basis for the lines and complete an

30   update of all lines once per month per wire center. Consequently, a loop qualification
database 104 is potentially one month out-of-date for a given wire center. The loop
qualification information on new numbers that have been activated within the last 30 days

will potentially not be present in the loop qualification database 104. According to the embodiment shown in Figure 10, HAL 110 receives a file with these new numbers each day and sends the file via FTP to the loop qualification system 100.

Figure 11 illustrates a flow diagram for the processing of these new numbers.

5   Each day, the NSPs 80 send the loop qualification system 100 e-mails with phone number files to qualify and the loop qualification system 100 responds with the loop qualification status for each of those numbers. At the first occurrence of a recent number, the loop qualification system 100 creates a file containing all of the recent numbers encountered during that day. The loop qualification system 100 responds to the NSP 80 by providing

10   the NSP 80 with a file in which recent numbers are marked with a status undetermined. The loop qualification system 100 also informs the NSP 80 to re-submit the number at a later time, such as after 24 hours. Subsequently, such as the next day, the loop qualification system 100 examines the existence of a recent-number file for the previous day. If the file exists, the loop qualification system 100 sends this file via FTP to HAL

15   110 and, if the file does not exist, no action will occur. For each new telephone number, HAL 110 generates a response file and places this file into a HAL update directory within database 104 in the loop qualification system 100. The loop qualification system 100 polls this directory on a periodic basis and, when the file is found, processes the response file by updating the loop qualification database 104.

20   A network according to a third embodiment of the invention is shown in Figure 12. The network includes a loop qualification system 120 having a loop qualification system database 104. The loop qualification system 120 has the back end interface 102 for interfacing with LEIS-LEAD 50 and HAL 110. As described above, LEIS-LEAD 50 contains a data snapshot of all the loops and all LMU data contained within LFACS 40

25   and is updated a monthly basis. The loop qualification system 120 receives LMU data on recent loops through HAL 110. The loop qualification system 120 also has a Navigator Contract interface 124 to a Regional Negotiation System (RNS) 132. The RNS 132 includes a Regional Ordering System (ROS) which together with RNS are responsible for receiving and marketing orders for digital services. The loop qualification system 120

30   also includes a CORBA interface 122 to the NSPs 80 and to an ADSL service order entry gateway 150. The CORBA interface 122 can display more or less detail as a function of the user ID. More detail can also be provided without requiring any upgrades at the NSPs

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80 or gateway 150.

For loop qualification requests that originate from RNS 132, the consumer service representative inputs the customer's address into RNS 132. The RNS 132 validates the address through an interface with RSAG 134 which returns a purified street address, wire

5   center name, and working/non-working lines in the location. The RNS 132 provides the loop qualification system 120 with the wire center, street address, and working phone numbers, if available, through the Navigator Contract interface 124. The loop qualification system 120 responds to this request by evaluating the data in the loop qualification system database 104. If the request includes an address, the system 120

10   qualifies all loops in a living unit, regardless of whether they have an assigned telephone number. If the RNS 132 sends telephone numbers in the request, the system 120 qualifies the telephone numbers without regard to the living unit. If the loops are not qualified for service, the loop qualification system 120 returns a message "no qualified loops." The loop qualification system 120 is preferably also to perform loop qualification on non-

15   working loops which may not presently have a phone number. The loop qualification system 120 can qualify such loops through a query by wire center and living unit ID (LU ID). For external queries, the system 120 takes requests that contain addresses and translates them into queries based on living unit.

The loop qualification system database 104 contains a number of files. The

20   database 104 is updated automatically from a variety of sources, such as LFACS 40 and LEIS-LEAD 50 through LEIS 50, LFACS data through HAL 110, and NPA-NXX-related files through PSIMS 140. For instance, the loop qualification system database 104 includes a wirecenter.lop file containing a network topology view pertaining to loop qualification for a given wire center. This file provides information on cross-boxes, F1

25   cables, and FN cables and loops related to a given wire center. A wirecenter.lu file contains the living unit records in LEIS 50 for a given wire center with each record containing the loop-ID field whereby the living unit may be related to a working, connect-through, or PC-data loop. An NPANXX.map file provides the relation between each wire center and the home NPA-NXX for that wire center and is sent automatically

30   from LEIS-LEAD 50 to the loop qualification system 120 whenever a wirecenter-to-NPANXX mapping is updated. A npa.spl file provides the mapping in the event of an NPA-NXX split and a number pooling file provides the wire center to NPA-NXX

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mapping. An ADSLWC.pri file provides information on wire centers that are ADSL DSLAM-equipped and provides the taper distance limit for each wire center. An ADSLXBOX.rem file provides information on cross-boxes associated with wire centers that are remote DSLAM-equipped and a date.csv file provides information on planned

5   dates for when certain loops will provide PC-data service. This file is generated by CMS 72 and is sent whenever planned PC-data service information is updated. Preferably, this file also specifies the wire center and living unit ID for each living unit in place of phone number. An ADSLWC.tpr file provides information necessary for the additional loop qualification conditions that are dependent on taper codes. This file is generated in LEIS

10   50 and sent to the loop qualification system 120 via FTP whenever the taper code-related information is updated. The loop qualification system database 104 also includes date_1.rsp and date_2.rsp files generated by HAL 110 and sent to the loop qualification system 120 via FTP. These files provide the loop qualification system 120 with data on specific recent loops.

15   The living unit, which has been mentioned above, is a new object class included in the object model. A preferred object model for the loop qualification system 120 is shown in Figure 13. The living unit represents the subscriber's living unit and is a copy of the living unit entity in LEIS 50. A living unit is characterized by a street address having a set of street address fields by which the living unit is characterized in LEIS 50.

20   These fields include unit, floor, building, house number, street, community, and state. The living unit is also identified by the LEU ID field.

          The loop qualification system object model also includes an object class for WireCenterArea. The object class of WireCenterArea has a primary purpose of tying each living unit in the database 104 to a particular wire center's jurisdiction in a semi-

25   permanent way. In the loop object class, the attribute of identifier, which stands for phone number, may be a phone number if the loop is a working POTS line. The identifier attribute may be blank if the loop is a non-working connect-through line or either blank or circuit ID if the loop has planned or available PC-data service. The loop class includes an attribute pe which indicates if the loop is working, connect-through, or some other status.

30   The loop object class also includes a loopId which is used to relay a loop object to a living unit object in the loop qualification system database 104. The capability class has a source attribute indicating the type of source from which the capability information was

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updated in the loop qualification system database 104.

Many organizations using or accessing the loop qualification system 120, such as the NSPs 80, need to provide an LQS interface to multiple users via a web server or some unique OS. The Loop Qualification System 120 provides "server accounts" to client

5   organizations, but for performance reasons, has to limit the number of LQS connections or Sessions. This raises the question of how to provide many independent users with concurrent access to an LQS Session.

One approach is to have all threads in a server compete for the same Java object LqsSession that controls communications with the LQS server. In this approach, one

10   Java Virtual Machine (VM) has *n* user threads, Thread *1* to Thread *n*. A similar architecture can apply to other types of servers, that is, Servlet could be replaced by an RMI server, DCOM server component, or CORBA server.

Each Servlet implements requests, which are discrete user actions, by invoking a qualify() method on the LqsSession singleton. Because web servers provide concurrent

15   access to many users, each user is assigned a *thread* context. Abstractly, a thread is a serial stream of program instructions. In this example, each Servlet instance runs in an independent thread. Because LqsSession.qualify() is declared *synchronized*, qualify() will accept control from one thread and block all other threads that attempt to call qualify() simultaneously. No exceptions are thrown; one blocked thread is simply

20   unblocked when the controlling thread exits the qualify() method. An effect of the single-threaded access to qualify() is that all requests are serialized: Request *2* must wait for Request *1* and Request *3* must wait for Request *2*. Under a light load, concurrent access to the LQS system 120 can be provided. But, if many requests are outstanding, the last thread serviced could be blocked for a considerable time. Worse, if the LQS system 120

25   cannot be reached for some reason or an operation does not complete, all threads will remain blocked and the server at the NSP 80 may require a restart to restore functionality.

Figure 14 illustrates a client Application Program Interface (API) for the LQS system 120 which has a multi-threaded interface. The API includes a LQS Multiplexor 250, which forms part of a Java library and Java Virtual Machine (VM) 270. Each thread

30   hosts an independent, client-implemented LQS server but each Servlet holds a distinct instance of a port rather than sharing the LqsSession 260. In general, a transmission *multiplexor* (MUX) 250 combines traffic from one or more multiplexor *ports* into a single

stream. Similarly, the LqsMux is a singleton Java object that multiplexes LQS qualification requests (from port objects) onto a single LQS Session 260. Each port operates in the context of the client thread, not the MUX thread.

The MUX 250 is responsible for managing the LqsSession object 260. The

5   LqsSession object 260 is responsible for handling authentication and recovery of the CORBA connection, as necessary. Under certain conditions, the CORBA ORB can become blocked, which will block the current LqsSession 260 operation. The MUX 250 detects such problems and recovers by instantiating a new LqsSession 260 and ORB.

When a thread invokes the qualify() operation on its port, the port will block until

10   the MUX services the request. If the port is not serviced in a specified interval, a time-out exception is thrown. The default time-out interval is 20 seconds. This time-out mechanism is safe in that it is completely independent of the LqsSession 260 and associated CORBA ORB.

A port-servicing algorithm operates as follows. In a quiescent state, the MUX 250

15   waits for a request from a port. As soon as a request is received, the MUX 250 sends it to the LQS system 120 and the response is returned. The MUX 250 returns the response to the port and unblocks its thread. Thus, intermittent requests are serviced immediately. As shown in Figure 14, a Request *l* triggers a request to the LQS 120 at time *t 2*. Each request can have 1 to a maximum number of telephone numbers (TN)/addresses

20   (AddressKeys), M, that can be sent in one LQS query. Thus, one query preferably does not contain any more than M TNs or AddressKeys.

An "Address Database" is made available to the NSPs 80 enabling them to translate a customer's address to an unambiguous Address Key which is then used to query LQS system 120. To take advantage of address-based qualification, the NSP 80

25   provides appropriate client-side processing to match a client address with the associated entry in the database. The database is available for download from the system 120, such as through a web site associated with the system 120.

The NSPs 80 match the user's address to the LQS acceptable Address-Key. The CORBA interface 122 accepts either the Address-Key or telephone numbers for Loop

30   Qualification Inquiries. The telephone number is accepted as 10-digit number and the Address-Key is accepted as a character string that begins with "@" sign and followed by 1 to 10 alphanumeric characters, as defined in the Address Database for each address.

The telephone number based loop qualification will return the ADSL capability of the line; the address-key based loop qualification will return the ADSL capability of the address.

An "AddressKey file" exists for each wire center with an example of a portion of

5   an AddressKey file being as follows:

0000000000~WireCenter~~zchrlama~~~~

old slaughter rd~4851~~~~zachary~3031C2E~15qt2

old slaughter rd~5463~~~~zachary~3031EA9~1up31.3

old slaughter rd~5107~~~~zachary~3031D80~1e1u2

10   old slaughter rd~5523~~~~zachary~3031ED0~1utt2

The format of each address line is:

<LivingUnit> ::= <LuAddress><sep><AddressKey><sep><ignore>

<LuAddress> ::=

        <StreetName><sep><StreetNumber><sep><BuildingId><sep>

15   FloorId><sep><UnitId><sep><CommunityId>

<sep> ::= '~'

To support address-based queries, the NSP 80 provides support for matching an actual customer address to a unique LuAddress in the AddressKey files. By giving the NSP 80 the raw address data, the NSP 80 has complete flexibility in how to lookup

20   addresses. Depending upon the needs of the NSP 80, this could be as sophisticated as an interactive GUI or as simple as performing Unix "grep" commands on the files. Regardless of the technique, a unique LuAddress is found. Then, the associated AddressKey can be used to query the LQS system 120. If there is at least one ADSL-capable loop at the physical LivingUnit, the LQS system 120 returns an 'A' or 'P'

25   response, otherwise, an 'N' with EA reason code is returned.

The MUX 250 preferably does not service ports sooner than t_m milliseconds from the last time any port was serviced. As shown at t_2 in Figure 14, Request2 and Request 3 are outstanding at t_2 so, the telephone numbers for Request 2 and Request 3 are combined into a single CORBA query and sent to the LQS 120. When the results are returned from

30   the LQS 120, the MUX 250 distributes them to the respective ports and the threads are unblocked. Assuming t_m is 3000 ms or 3 seconds, the average thread wait under heavy load would be 1.5 seconds and the worst-case is 3 seconds. Sporadic traffic should

average less than 1 second since the MUX 250 will service the request immediately.

        The LQS session abstraction represents an authenticated, possibly encrypted, private connection to the LQS server 120. The connection could be implemented with CORBA and the underlying implementation may use synchronous or asynchronous
5   communications. Further, some client applications may choose to use the LqsSession connection directly. While Java is the preferred language, the invention may be implemented with other languages.

        An example of a GUI interface to a loop qualification system is shown in Figure 15(A). Through this GUI interface, NSPs 80 or customer service representatives can
10   input telephone numbers and receive the status of those loops. Figure 15(A) shows the results for four different telephone numbers. The displayed status for each number is either A for available, P for planned, or N for not qualified. For qualified numbers, responses also include C for copper or F for fiber. For those numbers that are planned, the responses will also include the date when services plan to be available. For those
15   loops that are not qualified, the response also includes a code representing the reason that the numbers are not qualified. The GUI preferably has a transcript window that enables a user to qualify telephone numbers or addresses and record them in a scrolling window. The user is also able to store the output in a log file. An example of a transcript window is shown in Figure 15(B).

20   Figure 16 is an example of an interface for a bulk submit. In the preferred embodiment, a request may include up to one thousand numbers submitted in a single file. The loop qualification system 120 receives this file, processes the numbers contained within the file, and generates a file with responses for each number. Figure 16 shows the results for the same numbers used in the example of Figure 15 but submitted
25   through the bulk submit utility.

        The loop qualification system 120 preferably also rates the speed of the line. Since different levels of DSL service are available, the loop qualification system 120 provides some indication as to the highest level of service that may be available. For instance, the loop qualification system 120 provides a service rate code of A5 when the
30   calculated distance is 9 Kf which translates into a downstream rate of 2 to 6 Mb/s and an upstream rate of 128 Mb/s. When the loop qualification system 120 calculates the distance at 10 Kf, the line receives a service rate code of B5 meaning a downstream rate

of 1.5 Mb/s and an upstream rate of 128 Kb/s. The loop qualification system 120 assigns a service rate code of C5 at a calculated distance of 119 Kf which means that the line is qualified for a downstream rate of 768 Kb/s and an upstream rate of 128 Kb/s. The loop qualification system 120 assigns a service rate code of D5 at a calculated distance of 12.0

5   Kf for a downstream rate of 384 Kb/s and an upstream rate of 384 Kb/s. When the loop qualification system 120 determines that the calculated distance is 15.0 Kf, the system 120 assigns a service rate code of E5 for a downstream and upstream rate of 192 Kb/s. The service rate codes of A5, B5, C5, D5, and E5 are targeted for business rates whereas a service rate code of L0 is for a mass-market consumer rate and is assigned when the line

10   has a calculated distance of 18.0 Kf, the line is PC-data ready, or has a remote DSLAM. The service rate code of L0 corresponds to a downstream rate and upstream rate of the best effort, which may be 256 Kb/s.

In addition to qualifying loops, the loop qualification systems and methods of the invention provide additional advantages. The loop qualification system preferably tracks

15   the queries and also the responses and provides data available for analysis. This data allows for the generation of reports revealing where interest lies for service, such as by taper code, wire center, address, or NSP 80. With such information, planning for new lines, upgrades, new facilities, etc. can be focused in certain areas so as to maximize a return on investment. The data that is obtained from tracking the queries and responses is

20   preferably placed in a database that can be queried by network planners.

Furthermore, the invention may be used in combination with conventional or later developed techniques for qualifying lines. For example, the loop qualification systems according to the invention may be used to obtain an initial status of lines. In addition to relying upon the loop qualification systems, the invention may employ testing to audit

25   and purify the database. This testing may be performed at the central office or may be performed at least partially at the customer's premises.

The foregoing description of the preferred embodiments of the invention has been presented only for the purpose of illustration and description and is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Many modifications

30   and variations are possible in light of the above teaching.

For example, the invention is not limited to the precise types of interfaces described in the exemplary systems, such as a CORBA interface. The invention can be

implemented with web interfaces, XML interface, and other interfaces apparent to those skilled in the art upon reading this description.

The embodiments were chosen and described in order to explain the principles of the invention and their practical application so as to enable others skilled in the art to

5   utilize the invention and various embodiments and with various modifications as are suited to the particular use contemplated.

CLAIMS

What is claimed is:

1   1.   A method for qualifying lines for digital services, comprising:
2   collecting data on the characteristics of the lines from at least one source;
3   storing the data on the characteristics of the lines;
4 -   receiving a request inquiring as to a status of a line for digital services;
5   determining the status of a line for digital services by evaluating the data on the
6 characteristics of the lines; and
7   replying to the request with the status of the line for digital services.

1   2.   The method as set forth in claim 1, wherein the collecting of the data on the
2 characteristics of the lines comprises receiving engineering data on the lines.

1   3.   The method as set forth in claim 1, wherein the collecting of the data on the
2 characteristics of the lines comprises receiving inventory data.

1   4.   The method as set forth in claim 1, wherein the collecting of the data on the
2 characteristics of the lines comprises receiving data on planned lines.

1   5.   The method as set forth in claim 1, wherein the receiving of the request
2 comprises receiving the request from a service provider.

1   6.   The method as set forth in claim 1, wherein the receiving of the request
2 comprises receiving the request from a customer.

1   7.   The method as set forth in claim 1, wherein the receiving of the request
2 comprises receiving the request from a customer service representative.

1   8.   The method as set forth in claim 1, wherein the receiving of the request
2 comprises receiving a request for a plurality of lines.

1   9.   The method as set forth in claim 1, wherein determining the status of the
2   line comprises evaluating a status of a wire center for the line.

1   10.   The method as set forth in claim 1, wherein determining the status of the
2   line comprises evaluating a status of a taper code for the line.

1   11.   The method as set forth in claim 1, wherein determining the status of the
2   line comprises evaluating a resist zone for the line.

1   12.   The method as set forth in claim 1, wherein determining the status of the
2   line comprises evaluating a carrier zone for the line.

1   13.   The method as set forth in claim 1, wherein determining the status of the
2   line comprises evaluating a length of the line.

1   14.   The method as set forth in claim 1, wherein determining the status of the
2   line comprises evaluating a living unit for the line.

1   15.   The method as set forth in claim 1, wherein determining the status of the
2   line comprises determining an availability of digital services for the line.

1   16.   The method as set forth in claim 1, wherein determining the status of the
2   line comprises determining a speed of digital services appropriate for the line.

1   17.   The method as set forth in claim 1, wherein the receiving of the request and
2   the replying to the request with the status of the line occur in essentially real-time.

1   18.   The method as set forth in claim 1, wherein the receiving of the request and
2   the replying to the request occur in batch mode.

1   19.   The method as set forth in claim 1, wherein the receiving of the request and
2   the replying to the request with the status of the line occur over the Internet.

1   20.   The method as set forth in claim 1, wherein storing the data comprises
2   storing telephone numbers for the lines and receiving the request comprises receiving a
3   telephone number of the line.

1   21.   The method as set forth in claim 1, wherein storing the data comprises
2   storing addresses associated with the lines and receiving the request comprises receiving
3   an address associated with the line.

1   22.   The method as set forth in claim 1, wherein the receiving of the request
2   comprises receiving the request through an interface supported by an Internet
3   communications protocol.

1   23.   The method as set forth in claim 1, wherein the receiving of the request
2   comprises receiving the request through a graphical user interface.

1   24.   The method as set forth in claim 1, further comprising testing lines and
2   updating the data with results of the testing.

1   25.   The method as set forth in claim 1, further comprising tracking requests on
2   the status of the lines and replies with the status and generating reports from information
3   gathered from the tracking.

1   26.   A system for qualifying lines for digital service, comprising:
2   a database containing data on the characteristics of the lines;
3   an interface for receiving requests on the status of certain lines; and
4   a server for processing the requests by evaluating the data on the lines and for
5   determining a status of the lines;
6   wherein the server generates responses to the requests with the responses
7   indicating the status of the lines.

1   27.   The system as set forth in claim 26, further comprising a second interface
2   for receiving the data from a database containing engineering data on the lines.
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1   28.   The system as set forth in claim 26, further comprising a second interface
2   for receiving the data from a database containing inventory data on the lines.

1   29.   The system as set forth in claim 26, further comprising a second interface
2   for receiving data on planned lines.

1   30.   The system as set forth in claim 26, wherein the server generates the
2   responses in essentially real-time after receiving the requests through the interface.

1   31.   The system as set forth in claim 26, wherein the server receives the
2   requests and generates the responses in batch mode.

1   32.   The system as set forth in claim 26, wherein the database includes data on
2   wire centers and the server determines the status of the lines by evaluating the data on the
3   wire centers.

1   33.   The system as set forth in claim 26, wherein the database includes data on
2   taper codes and the server determines the status of the lines by evaluating the data on the
3   taper codes.

1   34.   The system as set forth in claim 26, wherein the database includes data on
2   the resist zone and the server determines the status of the lines by evaluating the data on
3   the resist zone.

1   35.   The system as set forth in claim 26, wherein the database includes data on
2   the carrier zone and the server determines the status of the lines by evaluating the data on
3   the carrier zone.

1   36.   The system as set forth in claim 26, wherein the database includes data on
2   lengths of the lines and the server determines the status of the lines by evaluating the
3   lengths.

1   37.   The system as set forth in claim 26, wherein the database includes data on

2   the living units of the lines and the server determines the status of the lines by evaluating

3   the living units of the lines.

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1   38.   The system as set forth in claim 26, wherein the responses generated by the

2   server indicate an availability of the digital services for the lines.

1   39.   The system as set forth in claim 26, wherein the responses generated by the

2   server indicate a speed of digital service appropriate for the lines.

1   40.   The system as set forth in claim 26, wherein the interface comprises a

2   CORBA interface.

1   41.   The system as set forth in claim 26, wherein the responses generated by the

2   server indicate a speed of digital service appropriate for the lines.

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FIGURE 1

FIGURE 2

CENTRAL OFFICE

30

DIGITAL FIBER

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ONU

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10
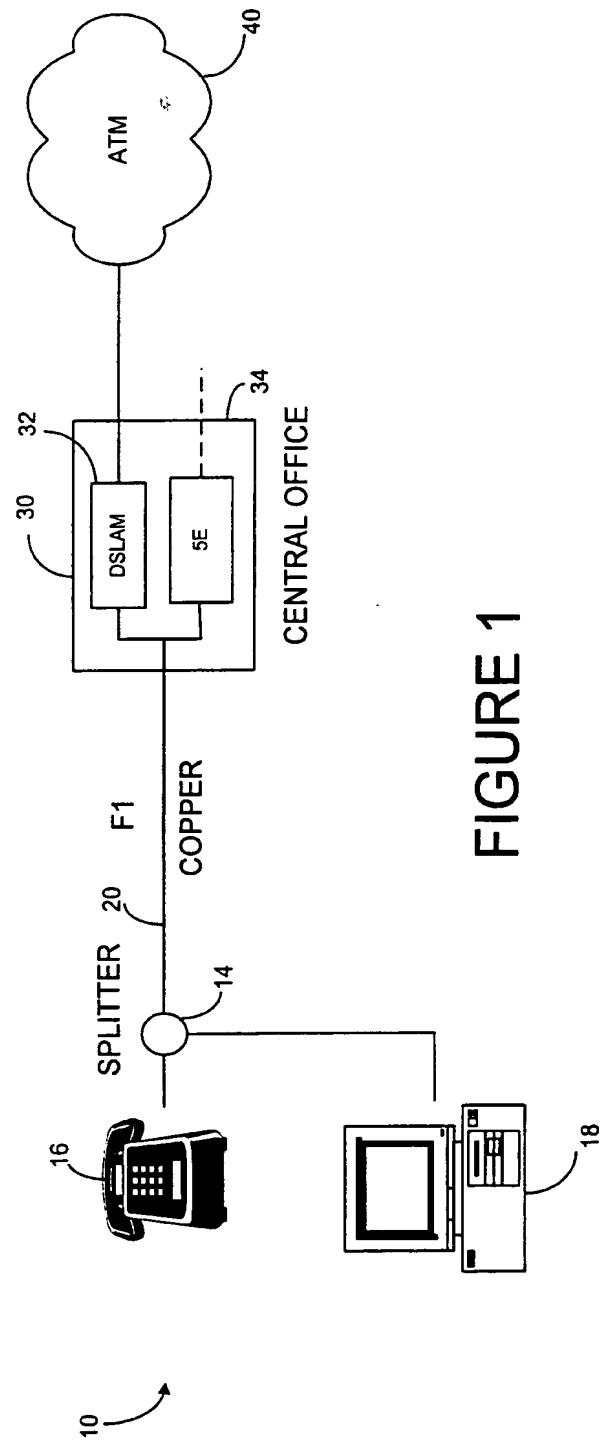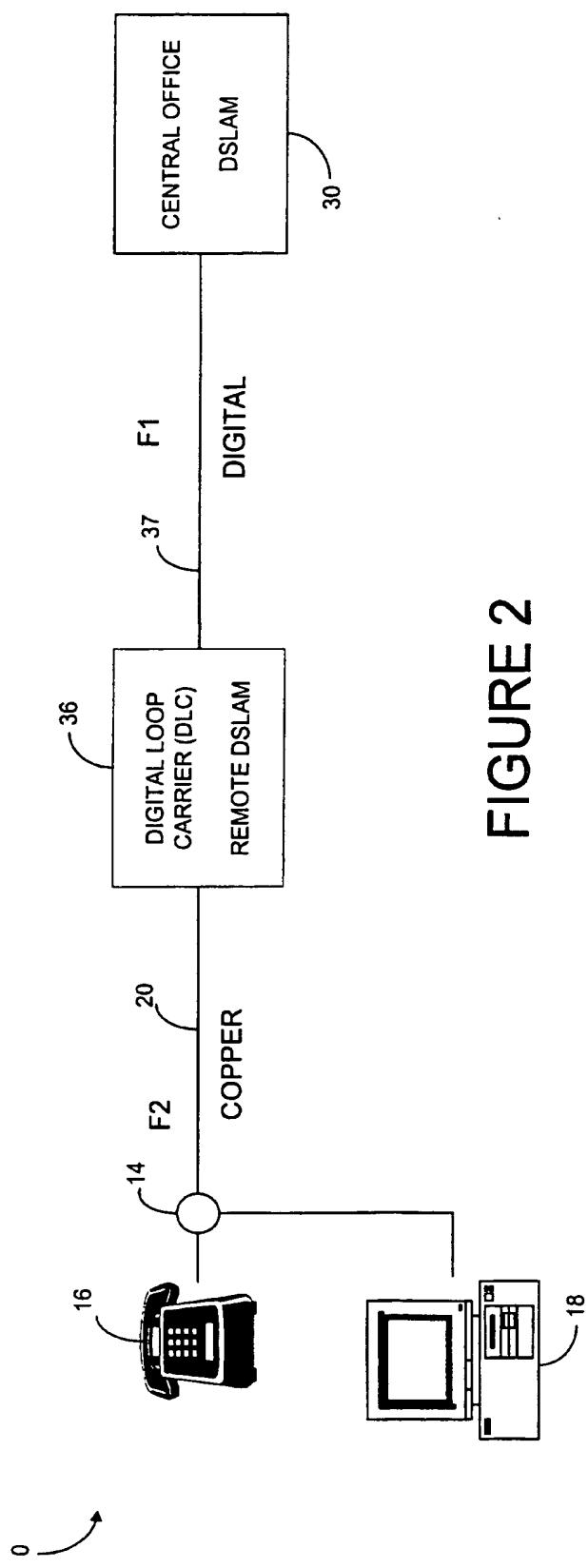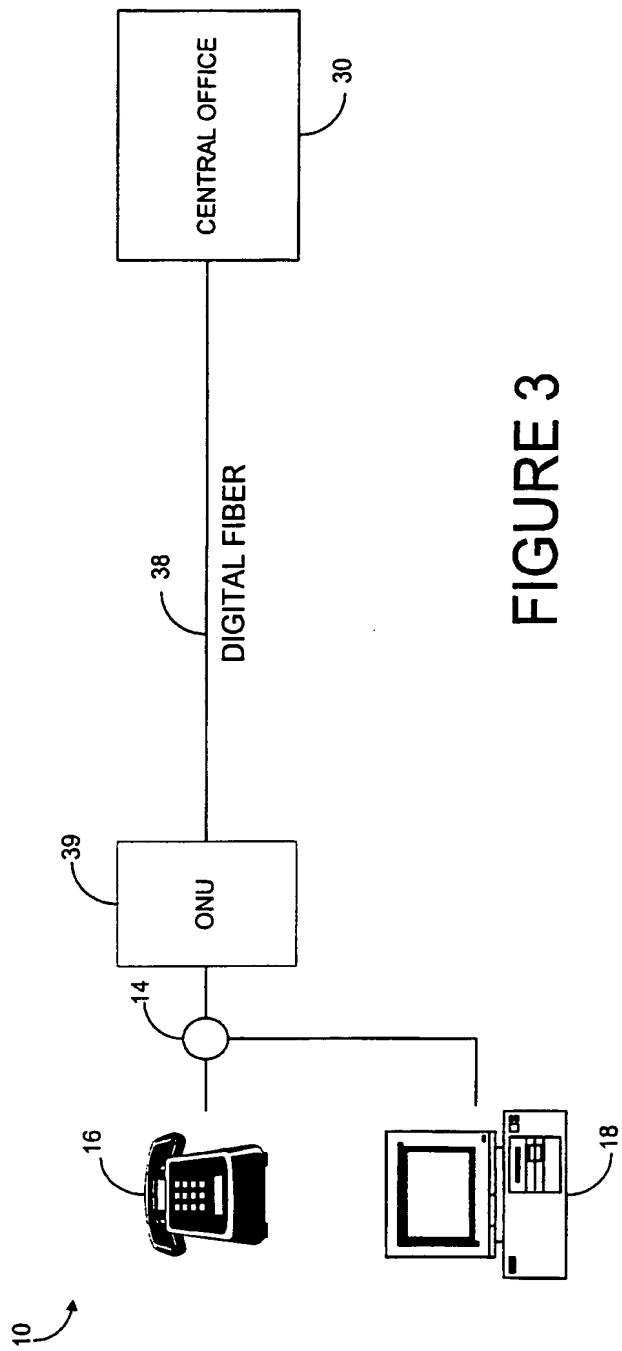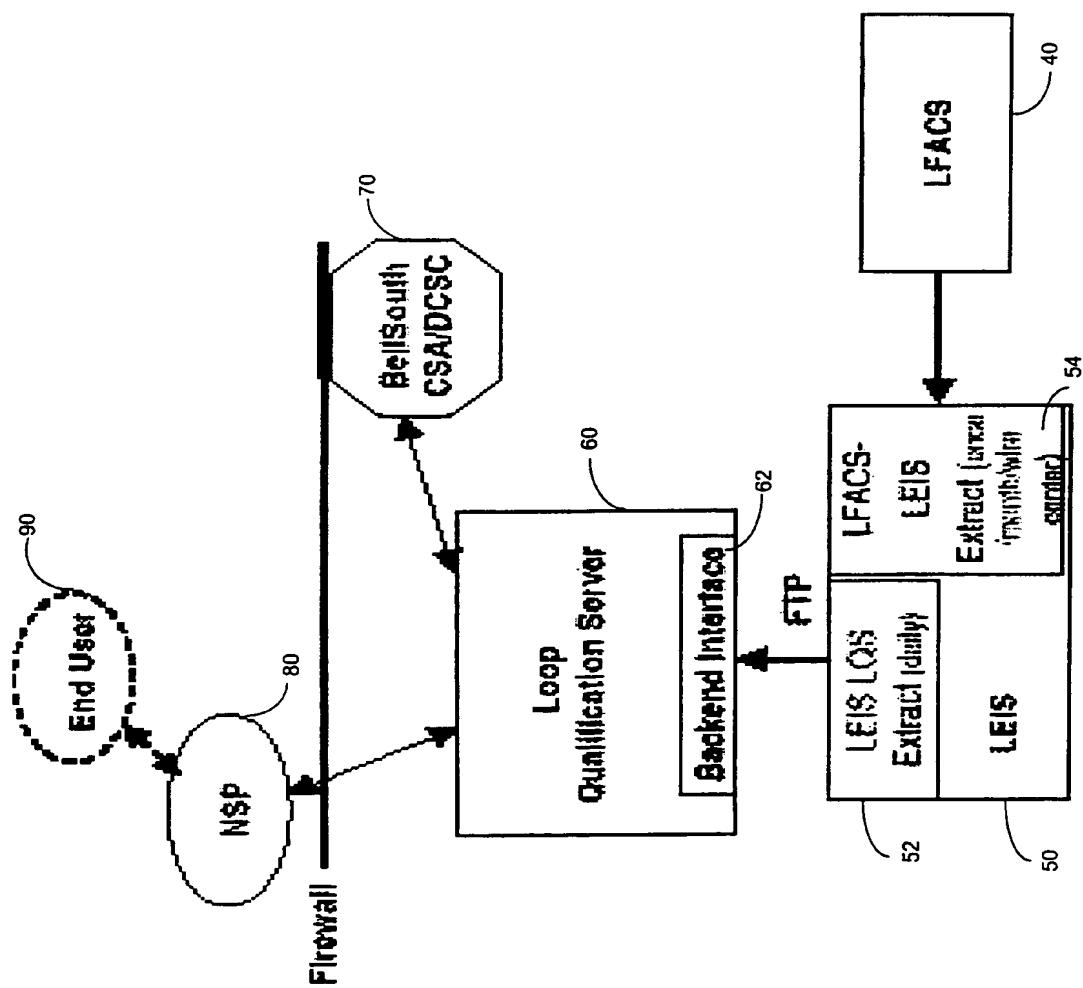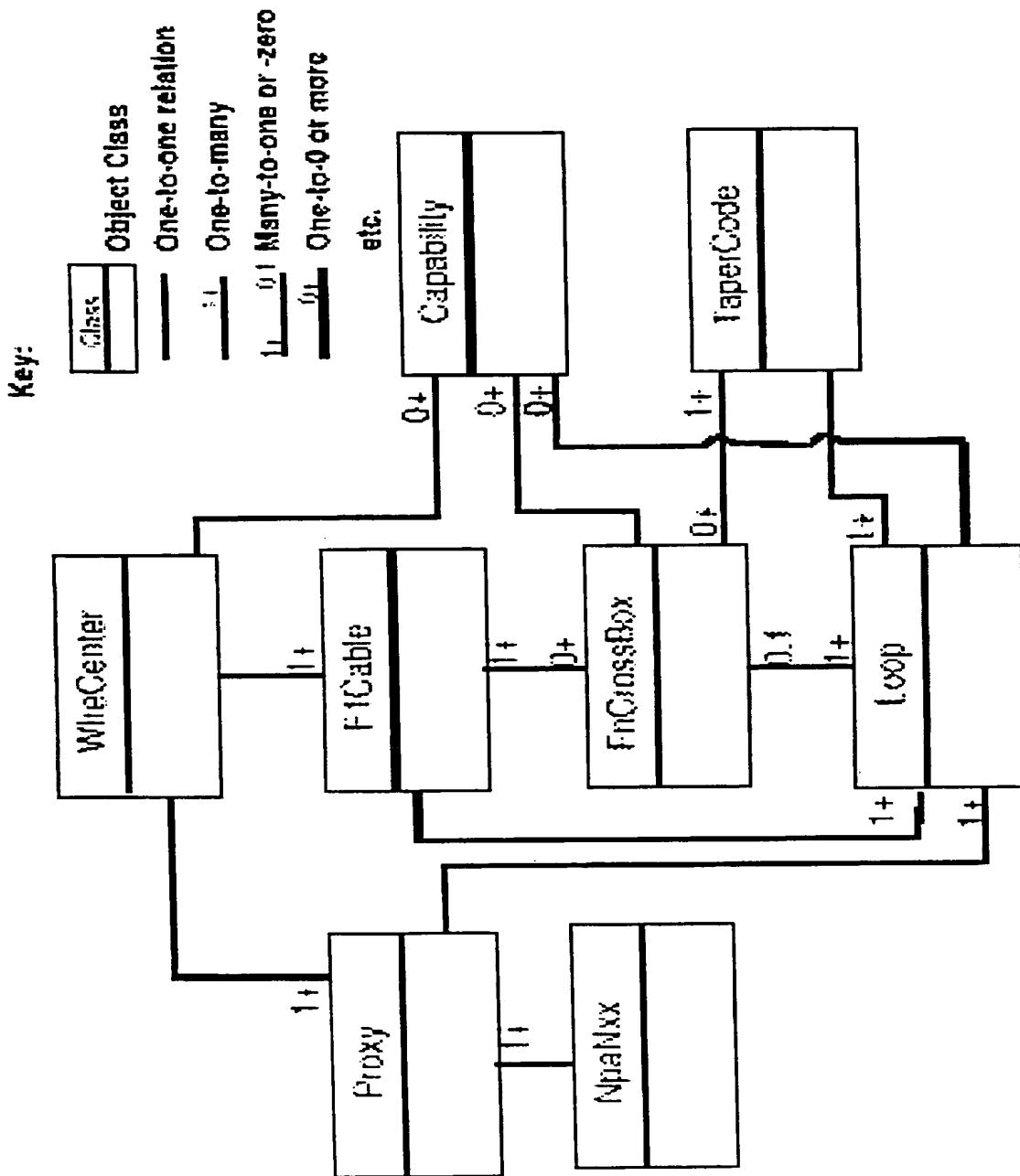
FIGURE 3
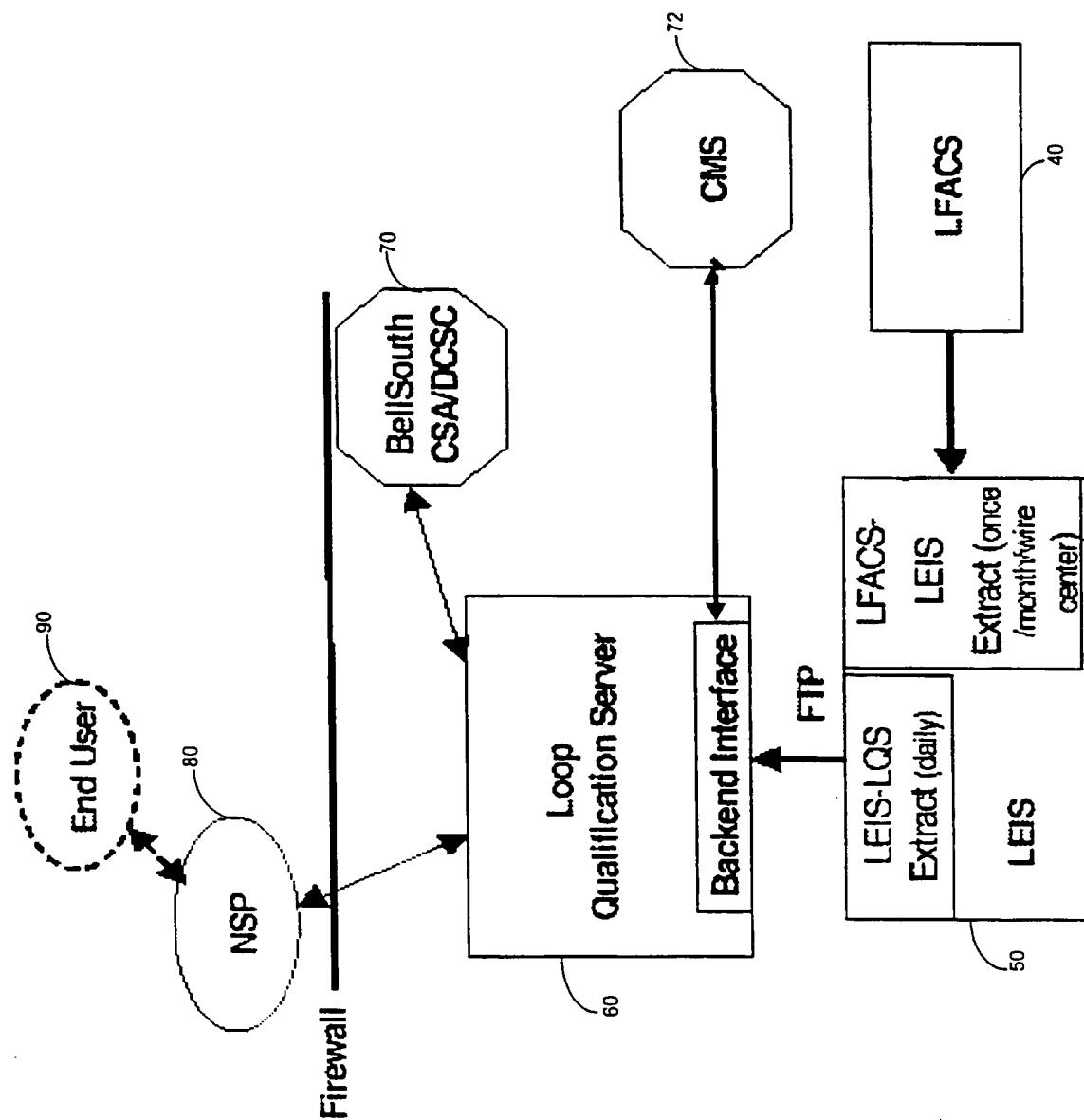
FIGURE 4

FIGURE 5

FIGURE 6
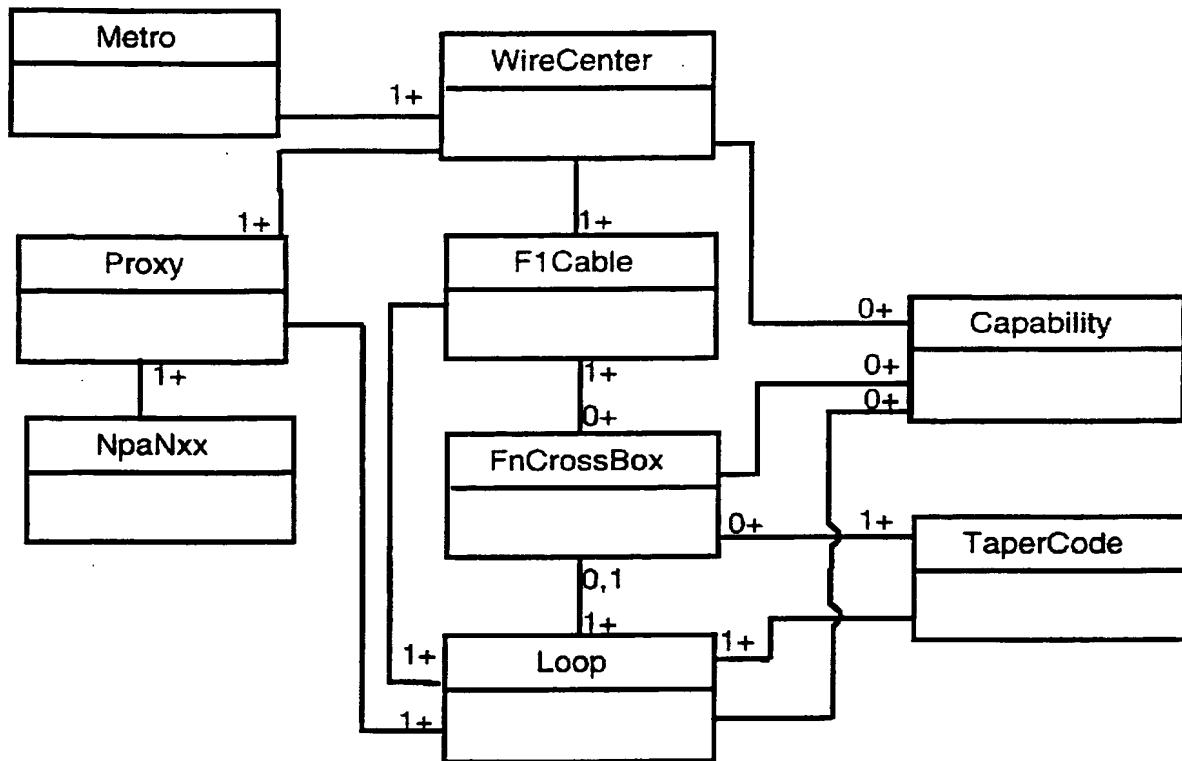
FIGURE 7
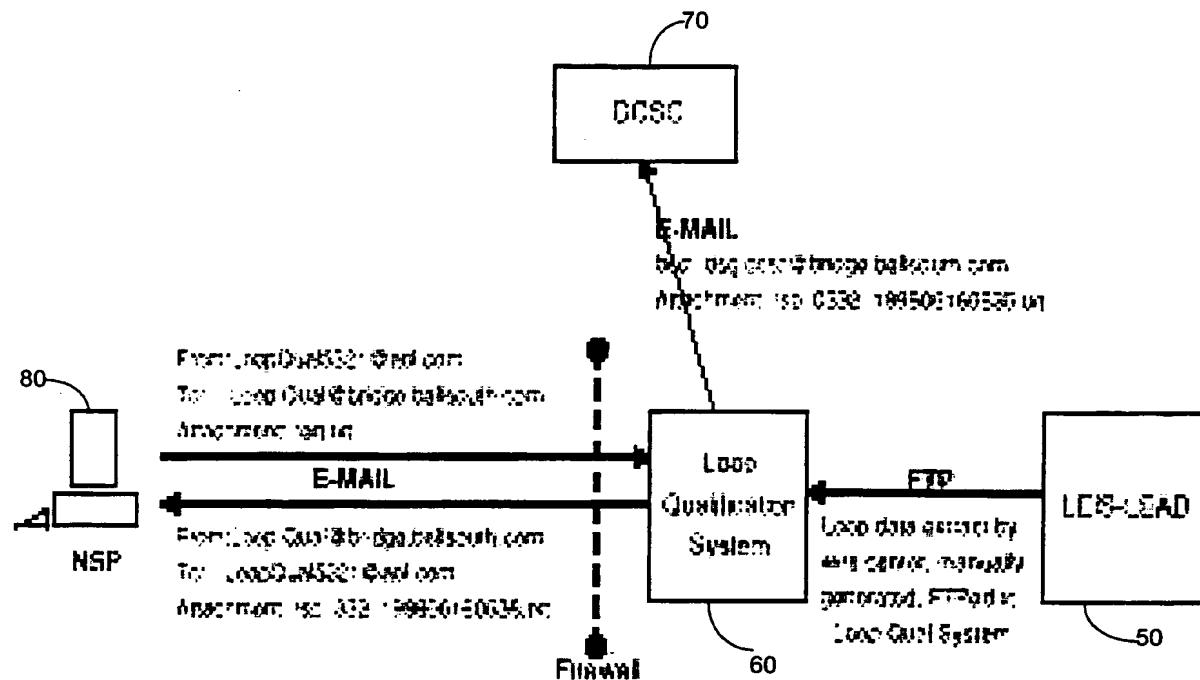
FIGURE 8
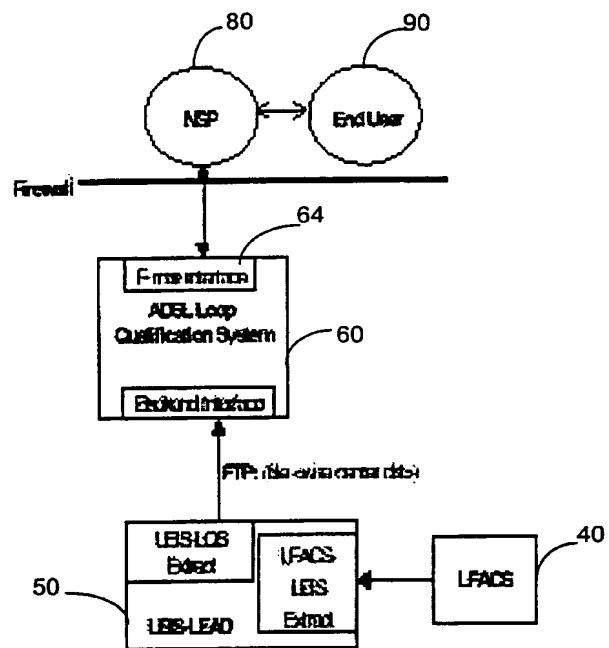
FIGURE 9
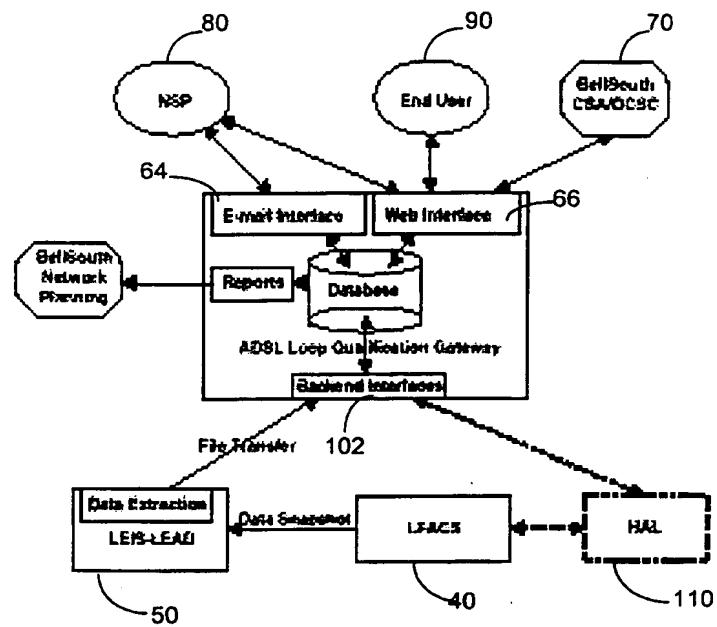
FIGURE 10
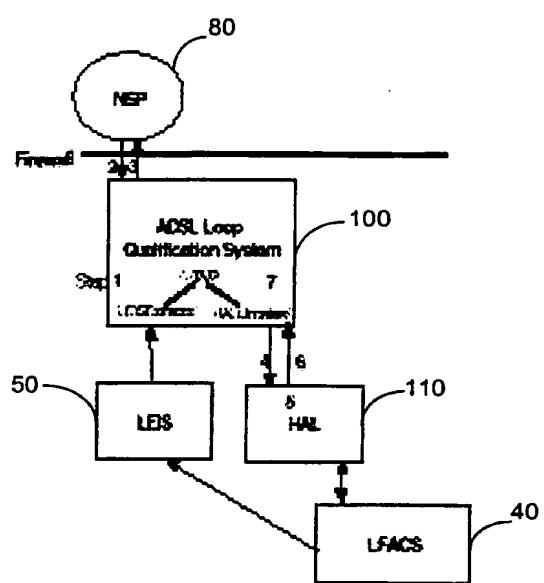
FIGURE 11
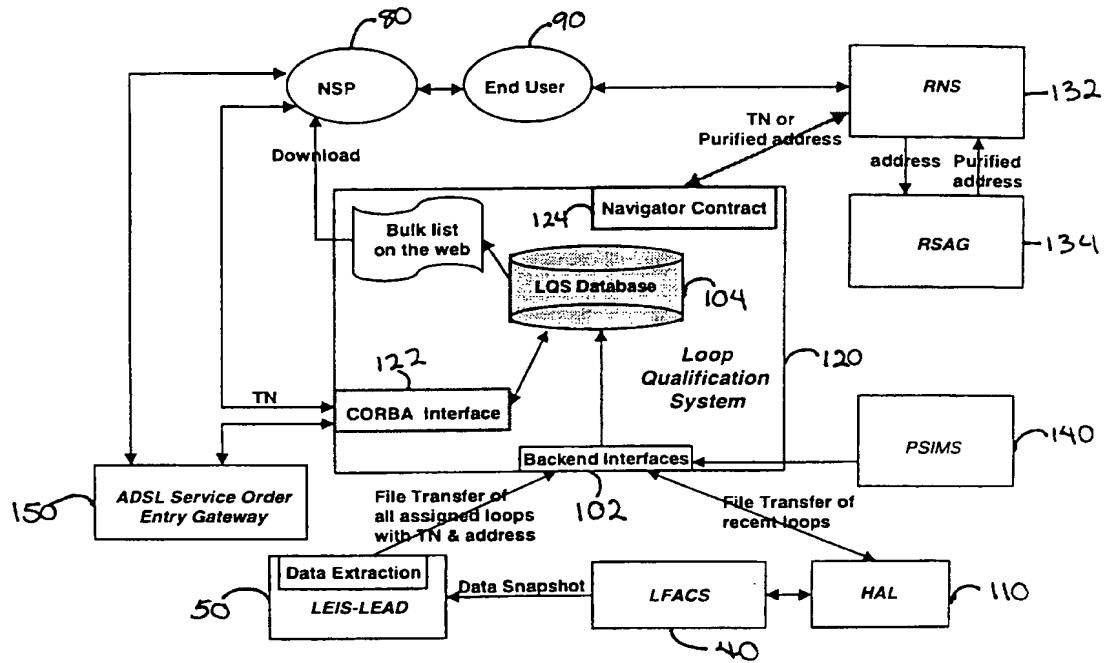
FIGURE 12
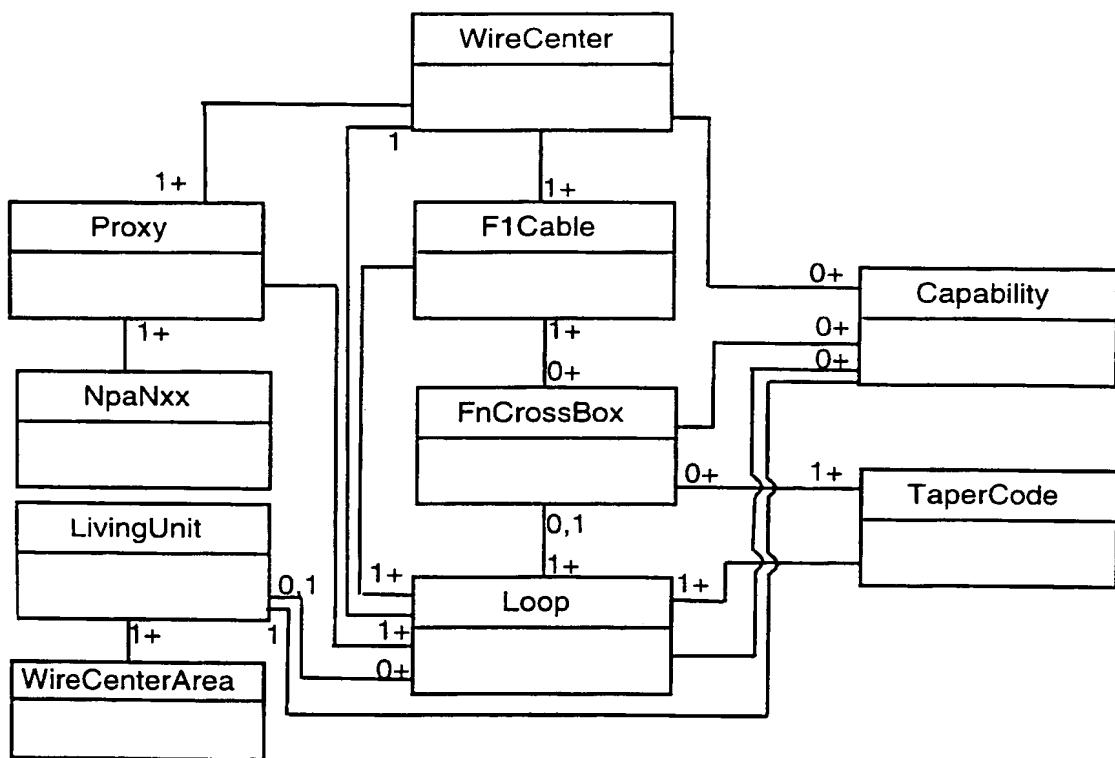
FIGURE 13
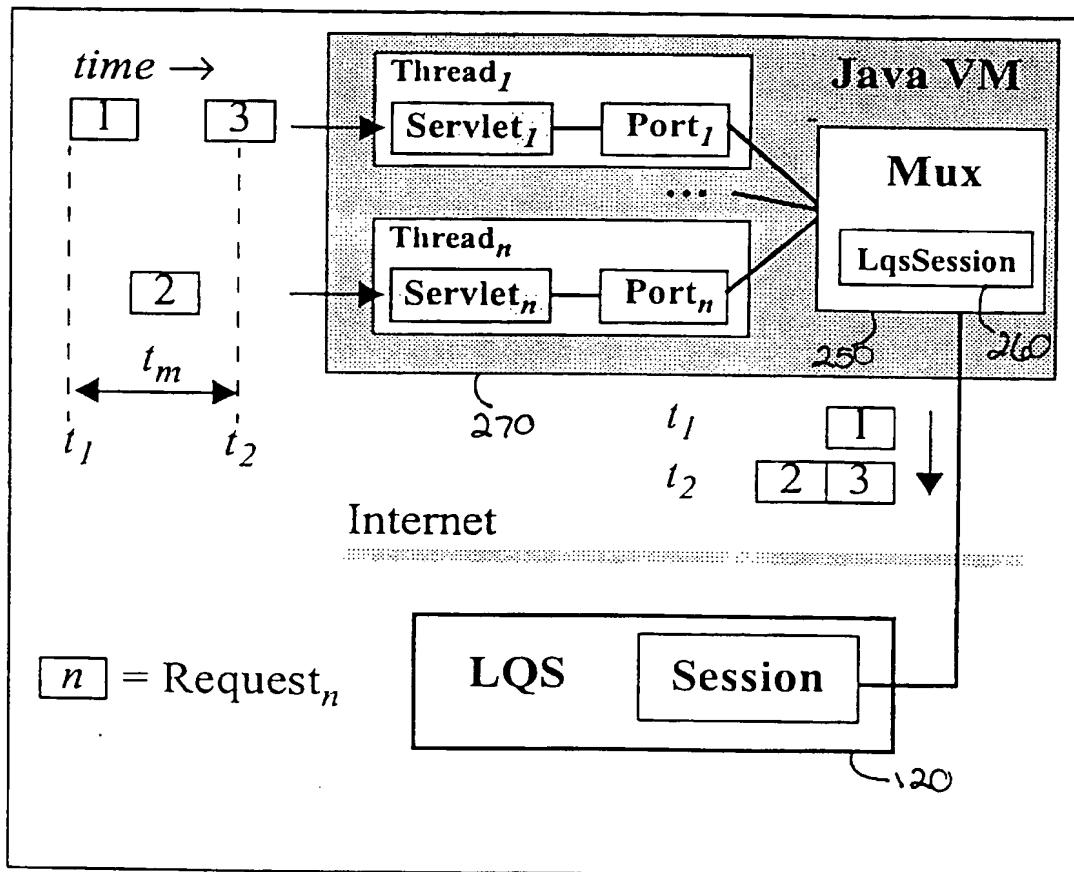
FIGURE 14
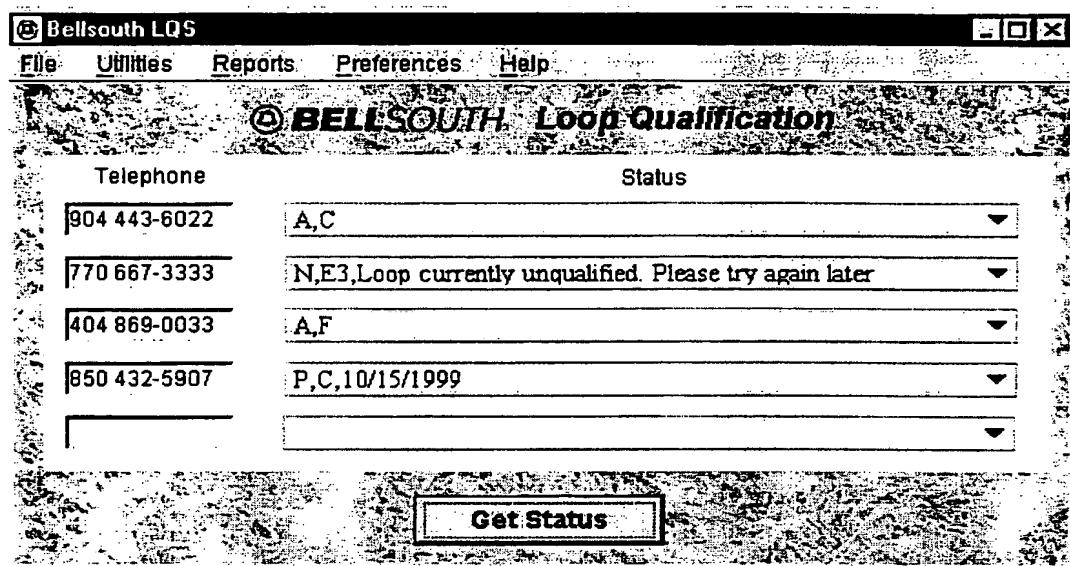
FIGURE 15(A)
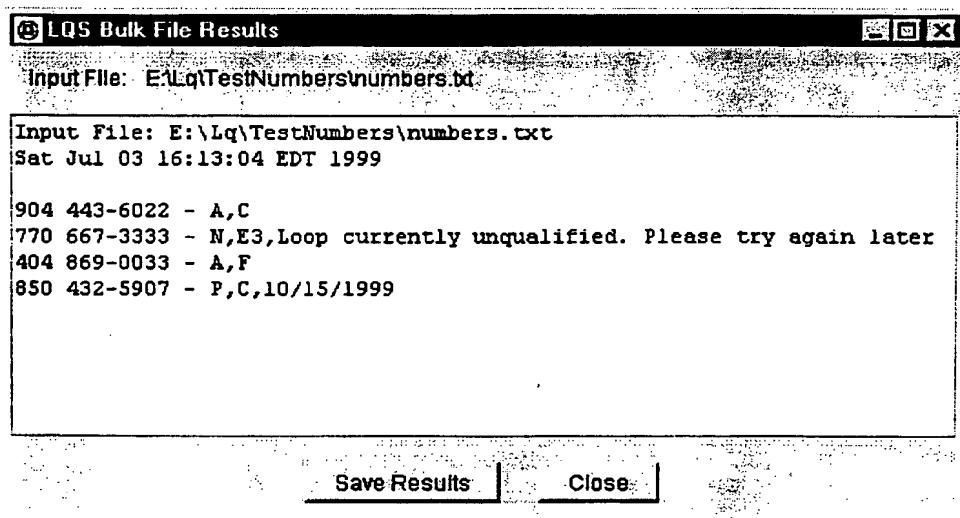
FIGURE 16
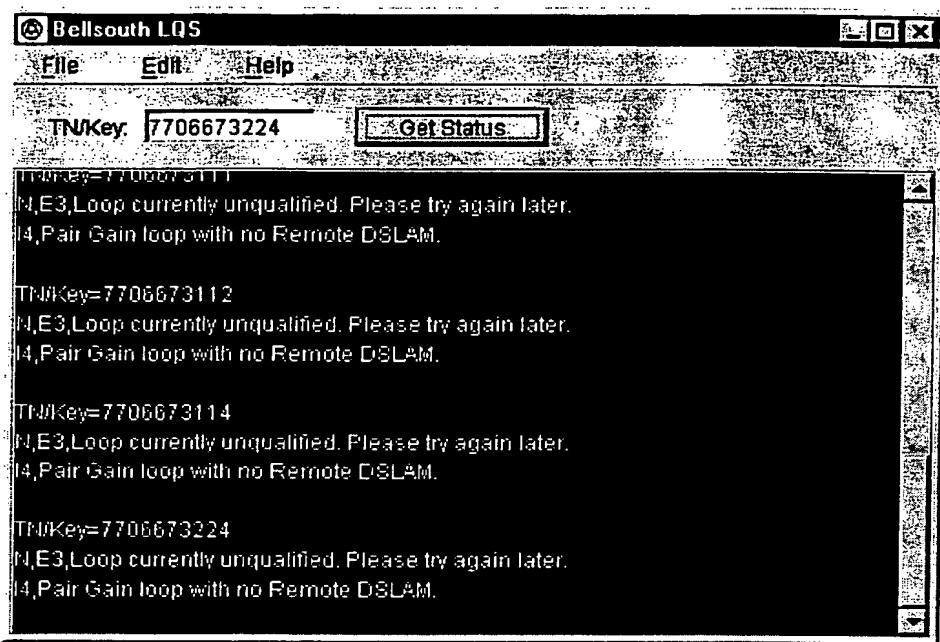
FIGURE 15(B)

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7   H04M3/30   H04B3/46

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7   H04M   H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	HEDLUND ET AL: "DSL Loop Test" TELEPHONY,CHICAGO, IL,US, vol. 235, no. 8, 24 August 1998 (1998-08-24), pages 48-52, XP002147002 ISSN: 0040-2656	1,2, 4-15,18, 26-29, 31-38
A	the whole document	3,16,17, 19-25, 30,39-41

A	WO 95 31865 A (KINGAN JONATHAN JAMES ;BRITISH TELECOMMMUNICATIONS PU (GB); COOK J) 23 November 1995 (1995-11-23) claim 1	1-41

A	US 5 864 602 A (NEEDLE JACK) 26 January 1999 (1999-01-26) column 2, line 32 - line 57	1-41

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[X] Further documents are listed in the continuation of box C.　　[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 December 2000	11/01/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office. P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040. Tx. 31 651 epo nl. Fax: (+31-70) 340-3016	Schweitz, M

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category°	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	WO 97 19543 A (VOELKER TECHNOLOGIES INC) 29 May 1997 (1997-05-29) page 3, line 12 - line 24 ---	1-41
P,A	US 6 084 946 A (BEIERLE JOHN) 4 July 2000 (2000-07-04) column 2, line 24 - line 58 -----	1-41

INTERNATIONAL SEARCH REPORT

...rormation on patent family members

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			AU	2451595 A	05-12-1995
			CA	2188879 A	30-11-1995
			CN	1148924 A	30-04-1997
			EP	0760189 A	05-03-1997
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			US	5841836 A	24-11-1998
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			US	5832071 A	03-11-1998
US 6084946	A	04-07-2000	NONE		